

RF Exposure Evaluation

Limit

The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in 1.1310 & 2.1091

Table 1-Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f ²)	6
30–300	61.4	0.163	1.0	6
300–1500	-	-	f/300	6
1500–100,000	-	-	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f ²)	30
30–300	27.5	0.073	0.2	30
300–1500	-	-	f/1500	30
1500–100,000	-	-	1.0	30

Note: f = frequency in MHz

Evaluation Method

Transmission formula: $P_d = (P_{out} * G) / (4 * \pi * R^2)$

Where

P_d = power density in mW/cm², P_{out} = output power to antenna in mW, G = gain of antenna in linear scale;

P_i = 3.1416, R = distance between observation point and center of the radiator in cm

Conducted Power Results

2.4G WIFI

Mode	Channel	Frequency (MHz)	Conducted Peak Output Power (dBm)
802.11b	1	2412	14.73
	6	2437	14.51
	11	2462	14.90
802.11g	1	2412	13.42
	6	2437	13.22
	11	2462	13.58
802.11n(HT20)	1	2412	12.81
	6	2437	12.86
	11	2462	12.91
802.11n(HT40)	3	2422	12.22
	6	2437	12.27
	9	2452	12.43

BT+EDR

Mode	Conducted Peak Output Power (dBm)
GFSK	6.19
$\pi/4$ DQPSK	8.10
8DPSK	8.36

5G WIFI

Mode	Channel	Frequency (MHz)	Conducted Peak Output Power (dBm)
11a	36	5180	13.21
	40	5200	13.42
	48	5240	13.28
802.11n(HT20)	36	5180	11.88
	40	5200	12.16
	48	5240	12.09
802.11n(HT40)	38	5190	11.35
	46	5230	11.62
11ac(VHT20)	36	5180	11.82
	40	5200	11.90
	48	5240	11.95
11ac(VHT40)	38	5190	11.16
	46	5230	11.37
11ac(VHT80)	42	5210	13.37

Manufacturing tolerance**2.4G WIFI**

802.11b			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	14	14	14
Tolerance $\pm$ (dB)	1	1	1
802.11g			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	13	13	13
Tolerance $\pm$ (dB)	1	1	1
802.11n20			
Channel	Channel 1	Channel 6	Channel 11
Target (dBm)	12	12	12
Tolerance $\pm$ (dB)	1	1	1
802.11n40			
Channel	Channel 3	Channel 6	Channel 9
Target (dBm)	12	12	12
Tolerance $\pm$ (dB)	1	1	1

BT+EDR

Mode	GFSK	$\pi/4$ DQPSK	8DPSK
Target (dBm)	5.5	7.5	7.5
Tolerance $\pm$ (dB)	1	1	1

5G WIFI

802.11a			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	13	13	13
Tolerance $\pm$ (dB)	1	1	1
802.11n20			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	11.5	11.5	11.5
Tolerance $\pm$ (dB)	1	1	1
802.11n40			
Channel	Channel 38	Channel 46	
Target (dBm)	11	11	
Tolerance $\pm$ (dB)	1	1	
802.11ac20			
Channel	Channel 36	Channel 40	Channel 48
Target (dBm)	11	11	11
Tolerance $\pm$ (dB)	1	1	1
802.11ac40			
Channel	Channel 38	Channel 46	
Target (dBm)	10.5	10.5	
Tolerance $\pm$ (dB)	1	1	
802.11ac80			
Channel	Channel 42		
Target (dBm)	12.5		
Tolerance $\pm$ (dB)	1		

Evaluation Results**2.4G WIFI**

Band/Mode	Antenna Distance (cm)	Conducted Output Power		Gain of antenna in linear scale	Power Density (mW/cm ²)	Limit (mW/cm ²)	Result
		dBm	mW				
802.11b	20	15	31.62	1.58	0.010	1.0	Pass
802.11g	20	14	25.12	1.58	0.008	1.0	Pass
802.11n20	20	13	19.95	1.58	0.006	1.0	Pass
802.11n40	20	13	19.95	1.58	0.006	1.0	Pass

BT+EDR

Band/Mode	Antenna Distance (cm)	Conducted Output Power		Gain of antenna in linear scale	Power Density (mW/cm ²)	Limit (mW/cm ²)	Result
		dBm	mW				
GFSK	20	6.5	4.47	1.58	0.001	1.0	Pass
π /4DQPSK	20	8.5	7.08	1.58	0.002	1.0	Pass
8DPSK	20	8.5	7.08	1.58	0.002	1.0	Pass

5G WIFI

Band/Mode	Antenna Distance (cm)	Conducted Output Power		Gain of antenna in linear scale	Power Density (mW/cm ²)	Limit (mW/cm ²)	Result
		dBm	mW				
802.11a	20	14	25.12	1.26	0.006	1.0	Pass
802.11n(HT20)	20	12.5	17.78	1.26	0.004	1.0	Pass
802.11n(HT40)	20	12	15.85	1.26	0.004	1.0	Pass
11ac(VHT20)	20	12	15.85	1.26	0.004	1.0	Pass
11ac(VHT40)	20	11.5	14.13	1.26	0.004	1.0	Pass
11ac(VHT80)	20	13.5	22.39	1.26	0.006	1.0	Pass

Remark:

1. Output power including tune up tolerance;
2. The maximum antenna gain for 2.4G is 2dBi and 1dBi for 5G
3. The exposure safety distance is 20cm.

Simulation Transmission

EUT can only work in 2.4G WiFi+ Bluetooth mode or 5G WiFi+ Bluetooth mode

The formula of calculated the Simulation Transmission MPE is:

$$CPD1 / LPD1 + CPD2 / LPD2 + \dots \text{etc.} < 1$$

CPD = Calculation Maximum Power Density

LPD = Limit of Power Density

Mode	Result
2.4G WiFi+ Bluetooth	0.012
5G WiFi+ Bluetooth mode	0.008

Conclusion

The measurement results comply with the FCC Limit per 47 CFR 1.1310 & 2.1091 for the uncontrolled RF Exposure and MPE compliance per KDB 447498 v06.